(d) Stack or duct diameter in ft (m) (determined in accordance with section 8.6 of Method 2F or Method 2G)

(e) Stack or duct radius in in. (cm)

(f) Distance from the wall of wall effects traverse points at 1-in. intervals, in ascending order starting with 1 in. (2.5 cm) (column A of Form 2H–1 or 2H–2)

(g) Point velocity values (v_d) for 1-in. incremented traverse points (see section 8.7.1), including d_{last} (see section 8.7.2)

(h) Point velocity value (v_{drem}) at d_{rem} (see section 8.7.3).

8.7.1 Point velocity values at wall effects traverse points other than d_{last}. For every 1-in. incremented wall effects traverse point other than d_{last}, enter in column B of Form 2H–1 or 2H–2 either the velocity measured at the point (see section 8.7.1.1) or the velocity measured at the first subsequent traverse point farther from the wall (see section 8.7.1.2). A velocity value must be entered in column B of Form 2H–1 or 2H–2 for every 1-in. incremented traverse point from d_1 (representing the wall effects traverse point 1 in. [2.5 cm] from the wall) to d_{last}.

8.7.1.1 For wall effects traverse points where the probe can be positioned and velocity pressure can be detected, enter the value obtained in accordance with section 8.6.

8.7.1.2 For wall effects traverse points that were skipped [see section 8.2.2.3(c)] and for points where the probe cannot be positioned or where no velocity pressure can be detected, enter the value obtained at the first subsequent traverse point farther from the wall where velocity pressure was detected and measured and follow the entered value with a "flag," such as the notation "NM," to indicate that "no measurements" were actually taken at this point.

8.7.2 Point velocity value at d_{last}. For d_{last}, enter in column B of Form 2H–1 or 2H–2 the measured value obtained in accordance with section 8.6.

8.7.3 Point velocity value (v_{drem}) at d_{rem}. Enter the point velocity value obtained at d_{rem} in column G of row 4a in Form 2H–1 or 2H–2. If the distance between d_{rem} and d_{last} is less than or equal to ½ in. (12.7 mm), the measured velocity value at d_{last} may be used as the value at d_{rem} (see section 8.2.4.2).

9.0 Quality Control.

9.1 Particulate Matter Build-up in Horizontal Ducts. Wall effects testing of horizontal circular ducts should be conducted only if build-up of particulate matter or other material in the bottom of the duct is not present.

9.2 Verifying Traverse Point Distances. In taking measurements at wall effects traverse points, it is very important for the probe impact pressure port to be positioned as close as practicable to the traverse point locations in the gas stream. For this reason, before beginning wall effects testing, it is important to calculate and record the traverse point positions that will be marked on each probe for each port, taking into account the distance that each port nipple (or probe mounting flange for automated probes) extends out of the stack and any extension of the port nipple (or mounting flange) into the gas stream. To ensure that traverse point positions are properly identified, the following procedures should be performed on each probe used.

9.2.1 Manual probes. Mark the probe insertion distance of the wall effects and Method 1 traverse points on the probe sheath so that when a mark is aligned with the outside face of the stack port, the probe impact port is located at the calculated distance of the traverse point from the stack inside wall. The use of different colored marks is recommended for designating the wall effects and Method 1 traverse points. Before the first use of each probe, check to ensure that the distance of each mark from the center of the probe impact pressure port agrees with the previously calculated traverse point positions to within ±¼ in. (6.4 mm).

9.2.2 Automated probe systems. For automated probe systems that mechanically position the probe head at prescribed traverse point positions, activate the system with the probe assemblies removed from the test ports and sequentially extend the probes to the programmed location of each wall effects traverse point and the Method 1 traverse points. Measure the distance between the center of the probe impact pressure port and the inside of the probe assembly mounting flange for each traverse point. The measured distances must agree with the previously calculated traverse point positions to within ±¼ in. (6.4 mm).

9.3 Probe Installation. Properly sealing the port area is particularly important in taking measurements at wall effects traverse points. For testing involving manual probes, the area between the probe sheath and the port should be sealed with a tightly fitting flexible seal made of an appropriate material such as heavy cloth so that leakage is minimized. For automated probe systems, the probe assembly mounting flange area should be checked to verify that there is no leakage.

9.4 Velocity Stability. This method should be performed only when the average gas velocity in the stack or duct is relatively constant over the duration of the test. If the average gas velocity changes significantly during the course of a wall effects test, the test results should be discarded.

10.0 Calibration

10.1 The calibration coefficient(s) or curves obtained under Method 2, 2F, or 2G and used to perform the Method 1 traverse are applicable under this method.

11.0 Analytical Procedure

11.1 Sample collection and analysis are concurrent for this method (see section 8).

12.0 Data Analysis and Calculations

12.1 The following calculations shall be performed to obtain a wall effects adjustment factor (*WAF*) from (1) the wall effects-unadjusted average velocity (*T4avg*), (2) the replacement velocity ($\hat{v}e_j$) for each of the four Method 1 sectors closest to the wall, and (3) the average stack gas velocity that accounts for velocity decay near the wall ($\hat{v}_{avg}$).

12.2 Nomenclature. The following terms are listed in the order in which they appear in Equations 2H–5 through 2H–21.

v_{avg}=the average stack gas velocity, unadjusted for wall effects, actual ft/sec (m/sec);

vi_i=stack gas point velocity value at Method 1 interior equal-area sectors, actual ft/sec (m/sec);

ve_j=stack gas point velocity value, unadjusted for wall effects, at Method 1 exterior equal-area sectors, actual ft/sec (m/sec);

i=index of Method 1 interior equal-area traverse points;

j=index of Method 1 exterior equal-area traverse points;

n=total number of traverse points in the Method 1 traverse;

$vdec_d$=the wall effects decay velocity for a sub-sector located between the traverse points at distances $d-1$ (in metric units, $d-2.5$) and d from the wall, actual ft/sec (m/sec);

v_d=the measured stack gas velocity at distance d from the wall, actual ft/sec (m/sec); Note: v_0=0;

d=the distance of a 1-in. incremented wall effects traverse point from the wall, for traverse points d_1 through d_{last}, in. (cm);

A_d=the cross-sectional area of a sub-sector located between the traverse points at distances $d-1$ (in metric units, $d-2.5$) and d from the wall, in.^{2} (cm^2) (e.g., sub-sector A_2 shown in Figures 2H–3 and 2H–4);

r=the stack or duct radius, in. (cm);

Q_d=the stack gas volumetric flow rate for a sub-sector located between the traverse points at distances $d-1$ (in metric units, $d-2.5$) and d from the wall, actual ft-in.^{2}/sec (m-cm^2/sec);

$Q_{d_1 \rightarrow d_{last}}$= the total stack gas volumetric flow rate for all sub-sectors located between the wall and d_{last}, actual ft-in.^{2}/sec (m-cm^2/sec);

d_{last}=the distance from the wall of the last 1-in. incremented wall effects traverse point, in. (cm);

A_{drem}=the cross-sectional area of the sub-sector located between d_{last} and the interior edge of the Method 1 equal-area sector closest to the wall, in.^{2} (cm^2) (see Figure 2H–4);

p=the number of Method 1 traverse points per diameter, $p \geq 8$ (e.g., for a 16-point traverse, p=8);

d_{rem}=the distance from the wall of the centroid of the area between d_{last} and the interior edge of the Method 1 equal-area sector closest to the wall, in. (cm);

Q_{drem}=the total stack gas volumetric flow rate for the sub-sector located between d_{last} and the interior edge of the Method 1 equal-area sector closest to the wall, actual ft-in.^{2}/sec (m-cm^2/sec);

v_{drem}=the measured stack gas velocity at distance d_{rem} from the wall, actual ft/sec (m/sec);

Q_T=the total stack gas volumetric flow rate for the Method 1 equal-area sector closest to the wall, actual ft-in.^{2}/sec (m-cm^2/sec);

$\hat{v}e_j$=the replacement stack gas velocity for the Method 1 equal-area sector closest to the wall, i.e., the stack gas point velocity value, adjusted for wall effects, for the j^{th} Method 1 equal-area sector closest to the wall, actual ft/sec (m/sec);

$\hat{v}_{avg}$=the average stack gas velocity that accounts for velocity decay near the wall, actual ft/sec (m/sec);

WAF=the wall effects adjustment factor derived from v_{avg} and $\hat{v}_{avg}$ for a single traverse, dimensionless;

$\hat{v}_{final}$=the final wall effects-adjusted average stack gas velocity that replaces the unadjusted average stack gas velocity obtained using Method 2, 2F, or 2G for a field test consisting of a single traverse, actual ft/sec (m/sec);

$\bar{WAF}$=the wall effects adjustment factor that is applied to the average velocity, unadjusted for wall effects, in order to obtain the final wall effects-adjusted stack gas velocity, $\hat{v}_{final}$ or, $\hat{v}_{final(k)}$, dimensionless;

$\hat{v}_{final(k)}$=the final wall effects-adjusted average stack gas velocity that replaces the unadjusted average stack gas velocity obtained using Method 2, 2F, or 2G on run k of a RATA or other multiple-run field test procedure, actual ft/sec (m/sec);

$v_{avg(k)}$=the average stack gas velocity, obtained on run k of a RATA or other multiple-run procedure, unadjusted for velocity decay near the wall, actual ft/sec (m/sec);

k=index of runs in a RATA or other multiple-run procedure.

12.3 Calculate the average stack gas velocity that does not account for velocity decay near the wall (v_{avg}) using Equation 2H–5.

$$v_{avg} = \frac{\left(\sum_{i=1}^{n-4} vi_i + \sum_{j=1}^{4} ve_j \right)}{n} \qquad \text{Eq. 2H-5}$$

(Note that v_{avg} in Equation 2H–5 is the same as $v_{(a)avg}$ in Equations 2F–9 and 2G–8 in Methods 2F and 2G, respectively.)

For a 16-point traverse, Equation 2H–5 may be written as follows:

$$v_{avg} = \frac{\left(\sum_{i=1}^{12} vi_i + \sum_{j=1}^{4} ve_j \right)}{16} \qquad \text{Eq. 2H-6}$$

12.4 Calculate the replacement velocity, $\hat{v}e_j$, for each of the four Method 1 equal-area sectors closest to the wall using the procedures described in sections 12.4.1 through 12.4.8. Forms 2H–1 and 2H–2 provide sample tables that may be used in either hardcopy or spreadsheet format to perform the calculations described in sections 12.4.1 through 12.4.8. Forms 2H–3 and 2H–4 provide examples of Form 2H–1 filled in for partial and complete wall effects traverses.

12.4.1 Calculate the average velocity (designated the ''decay velocity,'' $vdec_d$) for each sub-sector located between the wall and d_{last} (see Figure 2H–3) using Equation 2H–7.

$$vdec_d = \frac{v_{d-1} + v_d}{2} \qquad \text{Eq. 2H-7}$$

For each line in column A of Form 2H–1 or 2H–2 that contains a value of d, enter the corresponding calculated value of $vdec_d$ in column C.

12.4.2 Calculate the cross-sectional area between the wall and the first 1-in. incremented wall effects traverse point and between successive 1-in. incremented wall effects traverse points, from the wall to d_{last} (see Figure 2H–3), using Equation 2H–8.

$$A_d = \frac{1}{4}\pi(r-d+1)^2 - \frac{1}{4}\pi(r-d)^2 \qquad \text{Eq. 2H-8}$$

For each line in column A of Form 2H–1 or 2H–2 that contains a value of d, enter the value of the expression $\frac{1}{4}\pi(r-d+1)^2$ in column D, the value of the expression $\frac{1}{4}\pi(r-d)^2$ in column E, and the value of A_d in column F. Note that Equation 2H–8 is designed for use only with English units (in.). If metric units (cm) are used, the first term, $\frac{1}{4}\pi(r-d+1)^2$, must be changed to $\frac{1}{4}\pi(r-d+2.5)^2$. This change must also be made in column D of Form 2H–1 or 2H–2.

12.4.3 Calculate the volumetric flow through each cross-sectional area derived in section 12.4.2 by multiplying the values of $vdec_d$, derived according to section 12.4.1, by the cross-sectional areas derived in section 12.4.2 using Equation 2H–9.

$$Q_d = vdec_d \times A_d \qquad \text{Eq. 2H-9}$$

For each line in column A of Form 2H–1 or 2H–2 that contains a value of d, enter the corresponding calculated value of Q_d in column G.

12.4.4 Calculate the total volumetric flow through all sub-sectors located between the wall and d_{last}, using Equation 2H–10.

$$Q_{d_1 \rightarrow d_{last}} = \sum_{d=1}^{d_{last}} Q_d \qquad \text{Eq. 2H-10}$$

Enter the calculated value of $Q_{d_1 \rightarrow d_{last}}$ in line 3 of column G of Form 2H–1 or 2H–2.

12.4.5 Calculate the cross-sectional area of the sub-sector located between d_{last} and the interior edge of the Method 1 equal-area sector (e.g., sub-sector A_{drem} shown in Figures 2H–3 and 2H–4) using Equation 2H–11.

$$A_{drem} = \frac{1}{4}\pi(r-d_{last})^2 - \frac{p-2}{4p}\pi(r)^2 \qquad \text{Eq. 2H-11}$$

For a 16-point traverse (eight points per diameter), Equation 2H–11 may be written as follows:

$$A_{drem} = \frac{1}{4}\pi\left(r - d_{last}\right)^2 - \frac{3}{16}\pi(r)^2 \qquad \text{Eq. 2H-12}$$

Enter the calculated value of A_{drem} in line 4b of column G of Form 2H–1 or 2H–2.

12.4.6 Calculate the volumetric flow for the sub-sector located between d_{last} and the interior edge of the Method 1 equal-area sector, using Equation 2H–13.

$$Q_{drem} = v_{drem} \times A_{drem} \qquad \text{Eq. 2H-13}$$

In Equation 2H–13, v_{drem} is either (1) the measured velocity value at d_{rem} or (2) the measured velocity at d_{last}, if the distance between d_{rem} and d_{last} is less than or equal to ½ in. (12.7 mm) and no velocity measurement is taken at d_{rem} (see section 8.2.4.2). Enter the calculated value of Q_{drem} in line 4c of column G of Form 2H–1 or 2H–2.

12.4.7 Calculate the total volumetric flow for the Method 1 equal-area sector closest to the wall, using Equation 2H–14.

$$Q_T = Q_{d_1 \to d_{last}} + Q_{drem} \qquad \text{Eq. 2H-14}$$

Enter the calculated value of Q_T in line 5a of column G of Form 2H–1 or 2H–2.

12.4.8 Calculate the wall effects-adjusted replacement velocity value for the Method 1 equal-area sector closest to the wall, using Equation 2H–15.

$$\hat{v}e_j = \frac{Q_T}{\frac{1}{2p}\pi(r)^2} \qquad \text{Eq. 2H-15}$$

For a 16-point traverse (eight points per diameter), Equation 2H–15 may be written as follows:

$$\hat{v}e_j = \frac{Q_T}{\frac{1}{16}\pi(r)^2} \qquad \text{Eq. 2H-16}$$

Enter the calculated value of $\hat{v}e_j$ in line 5B of column G of Form 2H–1 or 2H–2.

12.5 Calculate the wall effects-adjusted average velocity, $\hat{v}_{avg}$, by replacing the four values of ve_j shown in Equation 2H–5 with the four wall effects-adjusted replacement velocity values, $\hat{v}e_j$, calculated according to section 12.4.8, using Equation 2H–17.

$$\hat{v}_{avg} = \frac{\left(\sum_{i=1}^{n-4} vi_i + \sum_{j=1}^{4} \hat{v}e_j\right)}{n} \qquad \text{Eq. 2H-17}$$

For a 16-point traverse, Equation 2H–17 may be written as follows:

$$\hat{v}_{avg} = \frac{\left(\sum_{i=1}^{12} vi_i + \sum_{j=1}^{4} \hat{v}e_j\right)}{16} \qquad \text{Eq. 2H-18}$$

12.6 Calculate the wall effects adjustment factor, WAF, using Equation 2H–19.

$$WAF = \frac{\hat{v}_{avg}}{v_{avg}} \qquad \text{Eq. 2H-19}$$

12.6.1 Partial wall effects traverse. If a partial wall effects traverse (see section 8.2.2) is conducted, the value obtained from Equation 2H–19 is acceptable and may be reported as the wall effects adjustment factor provided that the value is greater than or equal to 0.9800. If the value is less than 0.9800, it shall not be used and a wall effects adjustment factor of 0.9800 may be used instead.

12.6.2 Complete wall effects traverse. If a complete wall effects traverse (see section 8.2.3) is conducted, the value obtained from Equation 2H–19 is acceptable and may be reported as the wall effects adjustment factor provided that the value is greater than or equal to 0.9700. If the value is less than 0.9700, it shall not be used and a wall effects adjustment factor of 0.9700 may be used instead. If the wall effects adjustment factor for a particular stack or duct is less than 0.9700, the tester may (1) repeat the wall effects test, taking measurements at more Method 1 traverse points and (2) recalculate the wall effects adjustment factor from these measurements, in an attempt to obtain a wall effects adjustment factor that meets the 0.9700 specification and completely characterizes the wall effects.

12.7 Applying a Wall Effects Adjustment Factor. A default wall effects adjustment